Express Mail Label No. EV 22 39 59 414 US

UNITED STATES PATENT AND TRADEMARK OFFICE

Patent Application for an invention entitled

SYSTEM AND METHOD FOR ESTIMATING DISPLACEMENT OF A SEAT-BELTED OCCUPANT

By:

Samer R. White
a citizen of USA
residing at
6229 Branford Drive
West Bloomfield, Michigan 48322
USA

Prepared by:

Michael B. Stewart
Registration No. 36,018
Steven R. Thiel
Registration No. 53,685
Attorney Docket No.: 65858-0024/02-rASD-395
Customer No.: 010291
Rader Fishman & Grauer, PLLC
39533 Woodward Avenue, Suite 140
Bloomfield Hills, Michigan 48304
(248) 594-0633

SYSTEM AND METHOD FOR ESTIMATING DISPLACEMENT OF A SEAT-BELTED OCCUPANT

Field of the Invention

[0001] The present invention relates to the field of vehicle safety systems. More specifically, the present invention relates to a system for simulating the movement of a seat-belted occupant of a vehicle, along with a method of estimating the amount of horizontal displacement undergone by the seat-belted occupant.

Background of the Invention

[0002] Vehicle manufactures frequently utilize various systems and methods to simulate an occupant of a vehicle during sudden deceleration. These simulations typically allow the vehicle manufactures to predict the types of movement that the body of a vehicle occupant will undergo during a moment of sudden vehicle deceleration. The simulation results are then used to evaluate and improve various safety features found in modern vehicles. One such recent feature has been smart air bag systems, which monitor the actual position and motion of an occupant's body to determine an appropriate course of action.

[0003] In order to develop and test systems such as smart airbags, manufacturers need to be able to simulate and map the position and motion of a vehicle occupant during various conditions. However, existing methods of simulating the motion of a vehicle occupant are unable to provide a quick and simple way of accurately simulating the movement of a seat-belted occupant during a moment of vehicle deceleration and then estimate the resulting displacement of the seat-belted occupant from his original position.

Accordingly, the inventor of the present invention has developed a system and method for easily simulating the movement of a seat-belted occupant and estimating the amount of forward displacement that the occupant would be subject to due to sudden deceleration of the vehicle.

Summary of the Invention

[0004] The present invention relates to the field of vehicle safety, and more specifically, to a system and method of simulating the movement of a seat-belted occupant of a vehicle by subjecting a first, fixed point associated with a test dummy to a measurable amount of forward displacement with respect to a fixed frame of reference while limiting the amount of forward displacement that can occur at a second fixed point associated with the dummy with respect to the same frame of reference. Through the use of ratios, an amount of overall forward displacement undergone by the test dummy can then be estimated.

Brief Description of the Drawings

[0005] Figure 1 is a simplified illustration of a system for simulating a seat-belted occupant according to one embodiment of the present invention.

[0006] Figure 2 is a simplified illustration of how the system of Figure 1 operates.

[0007] Figure 3 illustrates the various distances and displacements used to determine the amount of horizontal or forward displacement that a seat-belted occupant may experience during deceleration of their vehicle.

Description of the Preferred Embodiment

[0008] A preferred embodiment of the present invention will now be described with reference to Figures 1 through 3. In general, a seat-belted occupant simulator 50 comprises two sections, including a mount 100 and an attached test dummy 200. Mount 100 includes a support guide 110 that establishes a fixed frame of reference with respect to the test dummy 200. Support guide 110 can be selectively fixed to a stationary structure, such as a wall or floor. Alternatively, mount 100 can be selectively fixed to an appropriate mobile structure, thereby allowing the simulator 50 to be easily moved from one location to another.

[0009] Located on support guide 110 is a drive guide 120 that is capable of being linearly displaced back and forth along the support guide 110. Movement of drive guide 120 relative to support guide 110 can be accomplished in numerous ways, ranging from something as simple as a human operator manually displacing drive guide 120 relative to support guide 110, to something more complex, such as a computer-controlled motor capable of accurately displacing drive guide 120 for various predetermined distances at one or more selectable velocities (not shown). To measure how much drive guide 120 is extended or displaced relative to support guide 110 at any moment in time, a displacement monitor 150 is incorporated into the mount system 100.

[0010] According to the present embodiment, a support brace 130 is affixed to the test dummy 200. Drive guide 120 then supports test dummy 200 by connecting to the support brace 130. As illustrated in the Figures, drive guide 120 connects to support brace 130 at point B. This connection at point B between drive guide 120 and support brace 130 functions as a pivot point, allowing the support brace 130, and subsequently the test dummy 200 affixed to support brace 130, to pivot or rotate about point B.

[0011] In order to simulate the tilting or leaning motion of a seat-belted occupant, one end of test dummy 200 must generally be fixed with respect to the fixed frame of reference represented in the current embodiment by the support guide 110. This is accomplished by various restraining systems 140 that, in general, prevent the fixed end of the test dummy 200 from undergoing any forward-directed lateral displacement. According to a first embodiment, not illustrated, restraining system 140 can comprise some form of mechanical or electro-mechanical brake or catch that secures point A of the mounting brace 130 from undergoing any forwardly-directed displacement relative to the support guide 110. For example, restraining system 140 can comprise a rigid bar or member that is fixed in length, and thus cannot be shortened through compaction or lengthened through extension. One end of the rigid member attaches to a point on the fixed frame of reference, such as one end of the support guide 110. The other end of the rigid member attaches either to the test dummy 200 or to the mounting brace 130 in such a manner that the test dummy 200 is restricted from any linear displacement in either a forwards or backwards direction with respect to the established fixed frame of reference. At the same time, however, the rigid member connects to the support brace 130 or test

dummy 200 in such a manner as to allow the support brace 130 and/or test dummy 200 to rotate or pivot about the connection point.

[0012] According to an alternate embodiment, as illustrated in the Figures, the restraining system comprises a flexible tether 140 that connects in-between support guide 110 and point A on the support brace 130. As in the prior embodiment discussed above, the connection at point A functions as a pivot point, permitting the support brace 130 and/or test dummy 200 to pivot or rotate about point A. However, unlike the prior embodiment, the flexible tether 140 prevents point A of the support brace 130 from undergoing any forward-directed displacement, relative to the support guide 110, only after the drive guide 120 has been extended by an amount that equals the length of the flexible tether 140. Accordingly, in this embodiment of the invention, simulations should only be considered active once the tether 140 is fully extended, thus assuring that point A of the support brace 130 cannot undergo any further forward-directed displacement.

[0013] To assure that measurements are taken only after tether 140 has been fully extended, an angle sensor or inclinometer (not shown) can be incorporated into the simulator system 50 at point B. Upon drive guide 120 extending far enough to equal the length of tether 140, the test dummy 200 will begin to tilt forward. The inclinometer mounted at point B will detect the tilting motion of test dummy 200 and can be setup to mark that point in time and space as the starting or reference point for all subsequent measurements or estimates obtained through use of the simulator system 50.

[0014] Operation of the seat-belted occupant simulator 50 will now be described with reference to the Figures. According to a first example, it is presumed that test dummy 200 is initially placed in a vertical orientation so that the length of test dummy 200 lies

perpendicular to the length of the support guide 110. This vertical orientation, as illustrated in Figure 1, best represents a vehicle occupant sitting upright in their seat. The motion that a vehicle occupant subsequently undergoes upon sudden deceleration of their vehicle is simulated by displacing drive guide 120 in a forward direction. This results in an upper portion of the test dummy 200 being displaced forward relative to the fixed frame of reference while the lower portion of the test dummy 200 is held in place due to the restraint system 140. Consequently, the test dummy 200 undergoes a tilting motion similar to that of a seat-belted occupant, leaning both forward and downward.

[0015] For purposes of evaluating safety systems such as seat belts and air bags, it is advantageous for a vehicle manufacturer to be able to estimate the amount of forward displacement undergone by an occupant's body at any point during a sudden deceleration situation. The seat-belted occupant simulator 50 is advantageous in this respect as it subsequently allows for an easy and rapid estimation of the amount of forward displacement undergone by the test dummy 200 by means of a simple ratio comparison.

[0016] When a vehicle occupant is caught in a state of sudden deceleration and their body is leaning or tilting forward, the outermost part of their body that faces in a forward direction will be the first portion of their body to likely impact the dashboard 300 or trigger an air-bag system. In the embodiment illustrated in the Figures, this outermost part of an occupant is presumed to be the nose, illustrated as point F on the test dummy 200, although any point on the test dummy 200 could be utilized.

[0017] To estimate the amount of forward displacement undergone by the outermost region (point F) of the test dummy 200, one must first determine the distance that drive guide 120 has been displaced in the forward direction relative to the support guide 110.

If the restraint system 140 that is being utilized is based on a flexible tether, then this determined amount of displacement must be evaluated in relation to the amount of forward displacement inherently allowed by the flexible tether. The overall amount of forward displacement undergone by drive guide 120 must then be reduced by the amount of displacement allowed by the tether, which is equivalent to the tether length. In the illustrated embodiment, the adjusted distance is graphically depicted in Figure 3 as the line connecting the two points labeled B and C, respectively. This distance BC can then be related to the distance or amount of forward displacement undergone by the upper portion of the test dummy 200, indicated in Figure 3 as the line connecting the two labeled points D and E. Specifically, the ratio DE/BC is assumed to be equal to the ratio of the distances AD/AB, where AD is the distance between point A on said mounting brace 130, and point D, representing the vertical height of the selected outermost point F of the test dummy 200. Similarly, distance AB represents the vertical distance that exists between points A and B on said mounting brace 130. As points A, B and D are all known, distances AB and AD, which are at right angles to distances BC and DE, can be readily determined. Knowing distances BC, AB and AD, unknown distance DE can then be readily estimated through the relationship:

$$DE = BC * (AD/AB)$$

Resultant distance DE represents the relative amount of horizontal or forward displacement undergone by the upper portion of test dummy 200. However, it does not take into account the position of the outermost part of the test dummy 200, represented by

point F. Accordingly, an offset representing the distance between point D and point F must be added to the calculated distance DE. The resultant amount of forward displacement undergone by test dummy 200 is then seen to be:

$$\text{Displacement} = BC * (AD/AB) + DF$$

In the above equation, the estimated offset distance DF is readily predetermined through measurement.

[0018] In addition to the distance or amount of forward displacement undergone by the test dummy, once can also readily estimate the velocity that the test dummy was subject to during its displacement. This is accomplished by simply recording the amount of time required to displace the test dummy from its initial starting position to its final displaced state, and then dividing the test dummy's estimated amount of forward displacement by this recorded amount of time.

[0019] While the invention has been specifically described in connection with certain specific embodiments thereof, it is to be understood that this is by way of illustration and not of limitation, and the scope of the appended claims should be construed as broadly as the prior art will permit.